

**ON-BOARD DEVICE, SIGNALING SYSTEM
AND CONTROL METHOD OF MOVING VEHICLE**

Technical Field

5 [0001]

The present invention relates to an on-board device, a signaling system and a method of controlling a moving vehicle, and especially, to an on-board device of a moving vehicle moving on a track, a
10 signaling system and a method of controlling the moving vehicle.

Background Art

[0002]

15 A moving vehicle (a train) traveling on a track as in a new transportation system and a railway is known. A signaling system which controls the traveling of such a moving vehicle is known. The conventional signaling system is of a central
20 supervisory control-type. In the central supervisory control-type signaling system, devices for a main safety function (a protection function) are concentrates in a control center and the traveling states of trains in a whole railroad division are
25 grasped and managed, in order to realize a function safety. The devices for the safety function (protection devices) contain an interlocking device, an ATP (Automatic Train Protection) ground device, and a station control device.

30 [0003]

FIG. 1 is a block diagram showing a configuration of the conventional signaling system. This signaling system is divided into a control center, (a group of) trains, stations and railroad
35 tracks. The control center grasps and manages the operation states of trains in the whole railroad

division, to realize the function safety. The control center contains an operation control device 230, an ATP ground device 232, a station control device 234 and an interlocking device 236. The respective
5 devices are mutually connected by an exclusive-use LAN (Local Area Network) 238 to be bi-directionally communicable. The operation control device 230 controls the whole operation. The interlocking device 236 carries out the protection of traveling routes of
10 the trains. The ATP ground device 232 prevents a collision between the trains. The station control device 234 attains the function safety of the control of the opening/closing of platform screen doors and train doors at a station.

15 [0004]

Each of the (group of) trains is provided with an on-board device 210. The on-board device 210 controls the operation of the train based on the control of the control center. The on-board device
20 210 is connected with the ATP ground device 232 by the exclusive-use LAN 250 to be bi-directionally communicable. The station is provided with a remote I/O 220. The remote I/O 220 carries out the opening/closing control of the platform screen door
25 240 and the control of railroad switches 250 on the railroad track based on the control of the control center. The remote I/O 220 is connected with the station control device 234 and the interlocking device 236 by an exclusive-use LAN 252 to be bi-directionally
30 communicable.

[0005]

The operation of this conventional signaling system (the operation of a train) becomes as described below, for example.

35 When a departure time of an optional train comes gets closer based on the train diagram, the

operation control device 230 refers to the on-rail state 205 from the ATP ground device 232 to check the on-rail state in the railroad division. When determining that the on-rail state indicates that the train is possible to depart, the operation control device 230 issues a departure command (or a traveling route request) 206 to the train.

[0006]

When receiving the departure command (or the traveling route request) 206, the interlocking device 236 refers to the on-rail state 205 in the railroad division to be received from the ATP ground device 232 at a constant period and issues a command to the remote I/O 220 such that the railroad switches (branches) 250 in an object section for which the train travels, become coincident with the direction of a traveling route. The remote I/O 220 controls the railroad switches (branches) 250 in the object section for which the train travels, to be switched to the traveling route direction. The interlocking device 236 locks the railroad switches (branches) 250 after the switching. As a result, the traveling route of the train is exclusively established (traveling route control 201). The other train never travels on the traveling route. The interlocking device 236 outputs the state of such a traveling route to the ATP ground device 232 at a constant period as a traveling route state 207.

[0007]

The ATP ground device 232 always monitors a train position by using a latest train position 204 received from detectors arranged on the railroad track and the train. The ATP ground device 232 outputs the on-rail state 205 in the railroad division which is based on the monitoring result, to the interlocking device 236 at a constant period. Also, the ATP ground

device 232 refers to the traveling route state 207
received from the interlocking device 236 at a
constant period, outputs a traveling permission 202 to
the train for which the traveling route is
5 established, while considering to keep a safety
distance from a preceding train. The train generates
a speed profile to a traveling permission limit
position when receiving the traveling permission 202,
and starts to travel under the speed control to be
10 carried out while referring to the profile.
[0008]

The station control device 234 receives a
train state 208 (the state in which the operation is
perfectly stopped and a brake is working) through the
15 ATP ground device 232, after the train has arrived at
a station. At the same time, the station control
device 234 checks a door state of a platform screen
door 240 through the remote I/O 220. After it is
confirmed that it is possible to open doors of the
20 train and the platform screen door 240, the station
control device 234 issues a door opening command 203
to (the on-board device 210 of) the train through the
ATP ground device 232. At the same time, the station
control device 234 issues a door opening command 203
25 to the platform screen door 240 through the remote I/O
220.
[0009]

In this way, in the conventional signaling
system, for example, the traveling route control is
30 carried out by the interlocking device 236 to
establish the traveling route of the train, and the
train interval protection for issuing the traveling
permission of the train is carried out by the ATP
ground device 232. In other words, in the
35 conventional signaling system, the traveling route
control and the train interval protection are carried

out by different systems.

[0010]

 This method is a method proved based on results but having a problem described below. For
5 example, the method has a processing system in which the protection functions are independent from each other, as mentioned above. Therefore, the conventional signaling system has a redundant configuration. Therefore, considering the system
10 configuration while paying attention to the safety of the signaling system, it is not possible to step out from the above configuration and there is a limit in the cost reduction.

[0011]

15 Also, when the signaling system is introduced, the operation control device 230, the interlocking device 236, the ATP ground device 232, and the station control device 234 become necessary to control the operations of all the trains in the whole
20 railroad division regardless of a railroad division scale and the details of the train operation. These are a minimum configuration when the signaling system is configured, and there is a limit in reduction of an introduction cost.

25 [0012]

 Especially, the operation control device 230, the ATP ground device 232, control device 234 and the interlocking device 236 control the operations of all the trains in the whole railroad division. Therefore,
30 each device is allocated with a very large load. For this reason, each device is extremely large in size and is expensive. Therefore, a technique is demanded in which a space for the device can be reduced, an introduction cost can be reduced, and the handling is
35 easy.

[0013]

As a related art, JP 2012-96704A discloses a radio train control system and a radio train control method. The radio train control system includes a central device, a station control device provided for
5 each railroad station and connected with the central device to be communicable, an on-board device provided in each train and connected with the station control device to be radio-communicable in a radio communication area of a station and a periphery of the
10 station. In this radio train control system, the on-board device includes transmission means for transmitting position information to the station control device. The station control device includes main operation means for receiving the position
15 information from the on-board device, storing on-rail information showing that the train is on a rail every partitioning section, transmitting the on-rail information to the central device, receiving instruction information from the central device, and
20 controlling devices in the station based on the instruction information. The central device includes main operation means for determining a traveling permission range of each train based on the on-rail information received from the station control device
25 and transmitting instruction information to the station control device. Moreover, the station control device further includes advance data storing means for setting advance data showing that the train advanced into the station, to a inerasable state when cannot be
30 normally communicated with the central device. The central device includes return means for receiving all the advance data from the station control device and returning to a main use operation from a temporary use operation after the partitioning sections where all
35 the trains are present are determined.

[0014]

Also, JP 2012-131324A discloses an operation security method and an operation security system. The operation security method is a method by the operation security system which includes 1) a control device
5 which manages an occupation state in each closed section, 2) a railroad switch control device which controls a railroad switch, and 3) an on-board device which is loaded into a train and carries out an interlocking control of the configuration of a
10 traveling schedule route based on each closed section and position information of the railroad switch. The method includes a securement request step in which the on-board device transmits a securement request signal to the control device to request the occupation
15 securement of the closed sections of a traveling schedule route; an occupation securing step in which the control device carries out a determination of whether or not all of the closed sections of the traveling schedule route meet a predetermined
20 occupation possible condition, based on the securement request signal, sets all the closed sections to occupation existence when meeting the predetermined occupation possible condition, and transmits a securement signal to the on-board device; a first
25 switching instruction step in which the on-board device transmits a switching instruction signal to a switch control device for a switch on the traveling scheduled route when receiving the securement signal; a switching step in which the switch control device
30 carries out the switch and lock operation to transmits a switching completion signal to the on-board device when receiving the switching instruction signal; a traveling permission step in which the on-board device permits the traveling to the traveling scheduled route
35 when receiving the switching completion signal; a release request step in which the on-board device

transmits a release request signal to request the occupation release of the closed section which the train has traveled; and an occupation release step in which the control device releases the occupation of a target closed section based on the release request signal.

Citation List

[0015]

- 10 [Patent Literature 1] JP 2012-96704A
[Patent Literature 2] JP 2012-131324A

Summary of the Invention

[0016]

- 15 Therefore, an object of the present invention is to provide a signaling system in which a space for devices and so on can be reduced. Also, another object of the present invention is to provide a signaling system in which an introduction cost can be reduced. Still another object of the present invention is to provide a signaling system in which the treatment of devices is easy.

[0017]

- 25 The present invention is related to an on-board device loaded on a moving vehicle traveling on a track. The on-board device has a control device configured to control the traveling of the moving vehicle. The control device includes: an operation data acquiring section, a route determining section, a traveling route securement determining section, and a traveling determining section. The operation data acquiring section acquires failure data indicating a failure on the track. The route determining section determines a traveling route in case of occurrence of the failure based on the failure data. The traveling route securement determining section determines
- 30
35

securement of the traveling route based on station
related data that is acquired from a station interface
device of a station to which a branch on the route
belongs and which indicates data of the branch, and
5 different moving vehicle related data that is acquired
from a different moving vehicle competing in at least
a part of the traveling route and that indicates data
of the different moving vehicle. The traveling
determining section determines the traveling of the
10 moving vehicle on the secured traveling route based on
the different moving vehicle related data.
[0018]

In the above on-board device, the traveling
route securement determining section may have a
15 different train state checking section, a station
state checking section and the traveling route
establishing section. The different train state
checking section inquires the different moving vehicle
related data to the different moving vehicle. The
20 station state checking section inquires the station
related data to the station to which the branch
belongs. The traveling route establishing section
outputs a branch switching command for the traveling
route to be secured, based on the station related data
25 and the other moving vehicle related data.
[0019]

In the above on-board device, the different
moving vehicle related data may contain a request time
data which indicates a time when the different moving
30 vehicle outputted a command of switching of the
branch. The traveling route securement determining
section may checks whether the traveling route has
been secured, based on the station related data and
the different moving vehicle related data. If there
35 is request time data that is earlier than the time
when the branch switching command is outputted from

the moving vehicle and if the traveling route has not been secured, the moving vehicle stands by at a predetermined stand-by position. The branch switching command may be outputted for the traveling route to be
5 secured after the different moving vehicle travels.
[0020]

In the above on-board device, the traveling route securement determining section may make the moving vehicle travel to the predetermined stand-by
10 position in case of the stand-by when the traveling route has not been secured.
[0021]

In the above on-board device, the different moving vehicle related data may contain the traveling
15 permission limit position data indicating a range where the moving vehicle is permitted to travel in case of the failure around the different moving vehicle. The traveling determining section may determine the traveling of the moving vehicle in the
20 range which the traveling is permitted, based on the traveling permission limit position data.
[0022]

A signaling system of the present invention has a plurality of on-board devices and a plurality of
25 station interface devices. The plurality of on-board devices are loaded in a plurality of moving vehicles traveling on the track and described in any one of the above paragraphs. The plurality of station interface devices are bi-directionally communicable, are
30 arranged in the plurality of stations provided along the track, and control the plurality of branches belonging to the plurality of stations.
[0023]

A control method of a moving vehicle of the
35 present invention is related to a control method of a moving vehicle traveling on a track. The control

method includes: acquiring failure data indicating a failure on the track by an on-board device of the moving vehicle; determining a traveling route in case of occurrence of the failure based on the failure data
5 by the on-board device; securing the traveling route by the on-board device based on station related data that is acquired from a station interface device of a station to which a branch on the traveling route belongs and which indicates data of the branch, and
10 different moving vehicle related data that is acquired from a different moving vehicle competing in at least a part of the traveling route and that indicates data of the different moving vehicle; and determining the traveling of the moving vehicle on the secured
15 traveling route based on the different moving vehicle related data by the on-board device.
[0024]

In the above control method of the moving vehicle, the securing the traveling route includes:
20 inquiring the different moving vehicle related data to the different moving vehicle by the on-board device; and inquiring the station related data to the station to which the branch belongs by the on-board device.
[0025]

25 In the above control method of the moving vehicle, the different moving vehicle related data may contain a request time data which indicates a time when the different moving vehicle outputted a command of switching of the branch. The securing the
30 traveling route may include: checking whether the traveling route has been secured, based on the station related data and the different moving vehicle related data; standing by at a predetermined stand-by position, if there is request time data that is
35 earlier than the time when the branch switching command is outputted from the moving vehicle and if

the traveling route has not been secured; and outputting the branch switching command for the traveling route to be secured after the different moving vehicle travels.

5 [0026]

In the control method of the moving vehicle, the securing the traveling route may include: making the moving vehicle travel to the predetermined stand-by position in case of the stand-by when the traveling
10 route has not been secured.

[0027]

In the above control method of the moving vehicle, the different moving vehicle related data may contain traveling permission limit position data which
15 indicates a range where the moving vehicle is permitted to travel in case of the failure around the different moving vehicle. The determining the traveling route may include: determining the traveling of the moving vehicle in the range where the moving
20 vehicle is permitted to travel, based on the traveling permission limit position data.

[0028]

A non-transitory recording medium of the present invention stores a program to make a computer
25 execute the control method of the moving vehicle according to any one of the above paragraphs.

[0029]

According to the present invention, the space of the devices and so on can be reduced. Also,
30 according to the present invention, the reduction of the introduction cost becomes possible. Moreover, according to the present invention, the treatment of the devices becomes easy.

35 **Brief Description of the Drawings**

[0030]

The object and other objects, advantages and features of the present invention could be understood in detail from the description of the following embodiments (examples), with reference to the
5 drawings.

[FIG. 1]

FIG. 1 is a block diagram showing a configuration of a conventional signaling system.

[FIG. 2]

10 FIG. 2 is a block diagram showing a configuration of a signaling system according to a first embodiment.

[FIG. 3]

FIG. 3 is a block diagram showing a
15 configuration example of the signaling system according to the first embodiment.

[FIG. 4A]

FIG. 4A is a block diagram showing a configuration example of a control device of an on-board device in the signaling system according to the
20 first embodiment.

[FIG. 4B]

FIG. 4B is a block diagram showing a configuration example of the control device of a
25 station I/F device in the signaling system according to the first embodiment.

[FIG. 5A]

FIG. 5A is a block diagram showing a configuration of a storage unit of the on-board device
30 in the signaling system according to the first embodiment.

[FIG. 5B]

FIG. 5B is a block diagram showing a configuration of the storage unit of the station I/F
35 device in the signaling system according to the first embodiment.

[FIG. 5C]

FIG. 5C is a block diagram showing a configuration of the storage unit of an operation control device in the signaling system according to the first embodiment.

[FIG. 6]

FIG. 6 is a diagram schematically showing a configuration example of a railroad line to which the signaling system according to the first embodiment is applied.

[FIG. 7]

FIG. 7 is a diagram schematically showing a scene of a train interval protection in case of inter-station traveling of a train in a station intermediate section.

[FIG. 8]

FIG. 8 is a flow chart showing an operation when the on-board device of the train communicates with other device.

[FIG. 9A]

FIG. 9A is a flow chart showing an operation of the train interval protection in case of inter-station traveling of the train in the station intermediate section.

[FIG. 9B]

FIG. 9B is a flow chart showing an operation when the on-board device of the train carries out branch release of the station I/F device.

[FIG. 10]

FIG. 10 is a block diagram showing a configuration example of a traveling route securement determining section of the control device in the signaling system according to a second embodiment.

[FIG. 11]

FIG. 11 is a diagram schematically showing the state of a railroad line to which the signaling

system according to the second embodiment is applied.
[FIG. 12]

FIG. 12 is a diagram schematically showing a scene of train interval protection in case of inter-station traveling of the train at a time of generation of a failure section.

[FIG. 13]

FIG. 13 is a flow chart showing an operation of the train interval protection in case of inter-station traveling of the train at a time of generation of the failure.

[FIG. 14]

FIG. 14 is a diagram schematically showing a state of a railroad line to which the signaling system according to a third embodiment is applied.

[FIG. 15]

FIG. 15 is a diagram schematically showing a scene of the train interval protection in case of inter-station traveling of the train in an end station portion.

Description of Embodiments

[0031]

Hereinafter, a signaling system according to embodiments of the present invention will be described with reference to the attached drawings.

In this signaling system, a protection function, which is achieved by a protection device (of an interlocking device, an ATP ground device, and a station control device) in the conventional signaling system, is provided in an on-board device of a moving vehicle (a train) in a different configuration. As a result, the on-board device judges traveling route securement autonomously and determines a traveling route (establishing a traveling route autonomously and permitting the traveling autonomously), and the train

interval protection can be autonomously carried out. Thus, the reduction of a device load in a control center, the reduction of a device space, the reduction of an introduction cost, and the easy handling of devices are realized. Hereinafter, the respective

[0032]

[First Embodiment]

1. Configuration

10 The configuration of a signaling system according to a first embodiment of the present invention will be described. FIG. 2 is a block diagram showing the configuration of the signaling system according to the present embodiment. The

15 signaling system 1 is divided into sections of a control center 4, (a group of) trains 2, stations 3 and railroad tracks 50.

[0033]

20 The control center 4 grasps an operation state of the trains 2 in the whole of railroad divisions. The control center 4 is provided with an operation control device 30. The operation control device 30 is connected with (on-board devices 10 of) the trains 2 and (station interface devices 20 of) the

25 stations 3 through a general-purpose LAN 60 to be communicable bi-directionally. The operation control device 30 receives data of the trains 2 (e.g. train positions 101) from the trains 2, receives data of platform screen doors, train doors and railroad

30 switches (e.g. door states 106, and railroad switch switching positions 104) from the stations 3, and displays them on a display unit (not shown). Also, the operation control device 30 sets an operation mode 105 and a train diagram of the train 2, and transmits

35 them to the trains 2 and the stations 3. The operation mode 105 is exemplified by a normal mode in

which a usual operation is carried out, and a failure mode in which a failure has occurred on a track. Any devices which have functions of the operation control device 230, the ATP ground device 232, the station control device 234, and the interlocking device 236, which are shown in FIG. 1, are not arranged in the control center 4.

[0034]

There are a plurality of trains 2. Each train 2 grasps an operation state of each of neighbor trains 2, manages its own operation, and realizes a function safety. The train 2 is provided with the on-board device 10. The on-board device 10 is connected with (a station I/F device 20 of) each of the stations 3 through the general-purpose LAN 60 to be communicable bi-directionally. The on-board device 10 checks a railroad switch switching position 104 indicating a switching position of each of railroad switches through the station 3, and controls the protection of a traveling route of the train 2 by carrying out a switching control 102 to switch the railroad switch according to necessity. Moreover, the on-board device 10 controls the collision prevention with a preceding train or a succeeding train by communicating with the preceding and succeeding trains 2. Moreover, the on-board device 10 carries out a door opening/closing control 103 to open or close the train door and the platform screen door in the station 3, to attain a function safety of the train door and the platform screen door. In this way, the on-board device 10 is provided with the protection function that has been attained by the protection device (of the interlocking device, the ATP ground device, and the station control device) in the conventional signaling system, in a different form. Therefore, the interlocking device, the ATP ground device, and the station control device

can be removed from the devices of the control center 4.

[0035]

There are a plurality of stations 3. Each of
5 the stations 3 carries out the opening/closing of the
platform screen door 40 and the switching of the
railroad switches 51 on the railroad track 50. The
station 3 is provided with the station I/F device
(station interface device) 20. The station I/F device
10 20 controls the opening/closing of the platform screen
door 40 based on the control of the on-board device
10. Moreover, the station I/F device 20 controls the
switching of the plurality of railroad switches 51 on
the railroad track 50 on the inbound side and the
15 outbound side in the neighborhood of the station 3
based on the control of the on-board device 10.
Moreover, the station I/F device 20 manages a
switching request to the railroad switches 51 from
each train 2. When the requests compete, the station
20 I/F device 20 does not accept the later switching
request.

[0036]

FIG. 3 is a block diagram showing a
configuration example of the signaling system
25 according to the present embodiment. The operation
control device 30 of the control center 4 is provided
with a center control device 31, a center storage unit
32 and a center communication device 33. The center
control device 31 is an information processing device
30 which is exemplified by a computer, and is provided
with a CPU (Central Processing Unit), a storage
section, an input section, an output section and an
interface, which are not shown. The center control
device 31 executes information processing for the
35 operation control device 30. The center storage unit
32 is a storage unit which is exemplified by a hard

disk drive, RAM (Random Access Memory) and ROM (Read Only Memory), and stores data and a software program which are used in the center control device 31, and data and a software program which are outputted from
5 the center control device 31. The center communication device 33 is a radio LAN transmitting and receiving unit which carries out a data communication through the general-purpose LAN 60. The center communication device 33 transmits data and the
10 software program which are outputted from the center control device 31, to the on-board device 10 and the station I/F device 20, and receives data and the software program which are transmitted from the on-board device 10 and the station I/F device 20 to
15 output to the center control device 31.
[0037]

The general-purpose LAN 60 is provided with a plurality of base stations 61. The plurality of base stations 61 are arranged in the control center 4 and
20 each station 3 and at a plurality of locations along the railroad track 500. The base station 61 mediates a radio communication among the operation control device 30, the plurality of the on-board devices 10 and the plurality of the station I/F devices 20 to
25 allow data to be sent and received among them. Note that in the present embodiment, an example using the radio LAN as the communication means is shown. However, different communication means may be used if it is possible to send and receive data among them.
30 [0038]

The on-board device 10 of the train 2 is provided with a control device 11, a storage unit 12 and a communication device 13. The control device 11 is an information processing device which is
35 exemplified by a computer, and is provided with a CPU, a storage section, an input section, an output section

and an interface, which are not shown. The control device 11 executes information processing for the on-board device 10. The storage unit 12 is a storage which is exemplified by a hard disk drive, RAM and ROM, and stores data and a software program which are used in the control device 11, and data and a software program which are outputted from the control device 11. The communication device 13 is a radio LAN transmitting and receiving unit which carries out a data communication through the general-purpose LAN 60. The communication device 13 transmits the data and the software program which are outputted from the control device 11, to the on-board device 10 of the operation control device 30, and another train 2, the station I/F device 20, and receives the data and the software program which are transmitted from the on-board device 10 of the operation control device 30, the other train 2 and the station I/F device 20 to output to the control device 11.

[0039]

Moreover, the train 2 is provided with a rotation count sensor 18 and a receiver 19. The rotation count sensor 18 detects the number of rotations of a wheel and a time change of them to output to the control device 11. The control device 11 calculates a position and speed of the train 2 based on the number of rotations and the time change of it. However, because the calculation of the position is carried out by integrating the number of rotations of the wheel, there is a possibility that an error comes out to an extent in case of a long-range integration due to the influences such as slip and tire abrasion. Therefore, a track antenna beacon (a transponder) 52 is installed in the railroad track at a predetermined interval and the position is corrected every time the data of the track antenna

beacon 52 is received, to prevent the accumulation of the error.

[0040]

The station I/F device 20 of the station 3 is
5 provided with a station control device 21, a station storage unit 22 and a station communication device 23. The station control device 21 is an information processing unit which is exemplified by a computer, and is provided with a CPU, a storage section, an
10 input section, an output section and an interface, which are not shown. The station I/F device 20 executes information processing for the station I/F device 20. The station storage unit 22 is a storage unit which is exemplified by a hard disk drive, RAM
15 and ROM, and stores data and a software program which are used in the station control device 21, and data and a software program which are outputted from the station control device 21. The station communication device 23 is a radio LAN transmitting and receiving
20 unit which carries out a data communication through the general-purpose LAN 60, transmits the data and the software program which are outputted from the station control device 21, to the operation control device 30, the on-board device 10 and the station I/F device 20
25 of the other station 3, and receives the data and the software program, which are transmitted from the operation control device 30, the on-board device 10 and the station I/F device 20 of the other station 3, to output to the station control device 21.

30 [0041]

Moreover, the station 3 is provided with the platform screen door 40. The station control device 21 detects a state of the platform screen door 40 and controls the opening/closing of the platform screen
35 door 40. Moreover, the station control device 21 is connected with the plurality of railroad switches 51

(a plurality of branches) on the railroad track 50, which are arranged in the neighborhood of the station 3. The railroad switch 51 is a branch of the railroad track 53. The station control device 21 detects the
5 state of each of the plurality of railroad switches 51 and controls the switching of each of the plurality of railroad switches 51.

[0042]

Next, the control device of the on-board
10 device 10 will be more described.

FIG. 4A is a block diagram showing a configuration example of the control device of the signaling system according to the present embodiment. In the control device, for example, the CPU develops a
15 computer program installed in the hard disk drive through an interface from a recording medium, in RAM (Random Access Memory). Then, the CPU executes the developed computer program, and realizes information processing of the computer program while controlling a
20 hardware configuration such as the storage section, the input section, the output section, the interface, the storage unit 12 and the communication device 13 according to necessity. The storage section and the storage unit 12 record the computer program and record
25 the data used by the CPU and the generated data. The input section outputs the data generated through operation by the user and another device to the CPU and the storage section. The output section outputs the data generated by the CPU and the data stored in
30 the storage section to the user and the other apparatus to be recognizable.

[0043]

The control device 11 grasps the operation states of neighbor trains 2, manages its own operation
35 and carries out a control for realizing a function safety. The control device 11 is provided with a

traveling route securement determining section 70, a traveling determining section 80, a train traveling control section 90 and a door control section 120. The traveling route securement determining section 70, 5 the traveling determining section 80, the train traveling control section 90 and the door control section 120 are realized by the computer program, or by cooperation between the computer program and the hardware configuration.

10 [0044]

The traveling route securement determining section 70 carries out a control for the protection of a traveling route of the train 2 itself. That is, the traveling route securement determining section 70 15 checks the securement of the traveling route based on station related data (to be described later) and different train related data (to be described later). Specifically, the traveling route securement determining section 70 checks the railroad switch 20 switching position showing the switching position of the railroad switch 51 through the station 3, and carries out the switching control to switch the railroad switch 51 according to necessity. The traveling route securement determining section 70 is 25 provided with an operation mode checking section 71, a different train state checking section 72, a station state checking section 73 and a traveling route establishing section 74. The operation mode checking section 71 checks the operation mode. The different 30 train state checking section 72 acquires the different train related data and checks the state of a different train 2. The station state checking section 73 acquires the station related data and checks the state of the station (e.g. the switching position of the 35 railroad switch 51 (a branch state)). The traveling route establishing section 74 switches the switching

position of the railroad switch 51 according to necessity and establishes (secures) the traveling route for the train 2.

[0045]

5 The traveling determining section 80 carries out a control for the collision prevention among the trains 2. That is, the traveling determining section 80 determines the traveling of the moving vehicle on the traveling route which was secured based on the
10 different moving vehicle related data. Specifically, the traveling determining section 80 communicates with the neighbor train 2 and grasps a range where the train 2 itself is permitted to pass or travel, and permits the passage of the train 2 in the range
15 (determines the traveling of the train 2 itself). The traveling determining section 80 is provided with a traveling permission limit position checking section 81. The traveling permission limit position checking section 81 checks a traveling permission limit
20 position of the train 2. Here, the traveling permission limit position shows a limit position where the traveling (moving) is permitted to the targeted train 2 (e.g. distance from a reference point, or distance to a preceding train).

25 [0046]

 The train traveling control section 90 carries out a control for the train 2 to move (travel) based on a train diagram of the train 2, a position of the train 2, and the traveling permission limitation
30 position. The train traveling control section 90 is provided with a traveling section 91, a speed profile generating section 94 and a train diagram checking section 95. The traveling section 91 drives the train 2 to travel. The train diagram checking section 95
35 checks the train diagram of the train 2 and issues a departure command at a departure time. The speed

profile generating section 94 generates a speed limit profile showing an upper limit value of speed when traveling from a current station at which the train 2 is in a stop state to a next stop station, based on a distance from the targeted train 2 to the traveling permission limitation position.

[0047]

The door control section 120 carries out a control for the function safety of the doors of the train 2 and the platform screen door by controlling the opening/closing of the doors of the train 2 and the platform screen door 40 in the station 3.

[0048]

Next, the station control device 21 of the station I/F device 20 will be more described.

FIG. 4B is a block diagram showing a configuration example of the station control device 21 of the signaling system according to the present embodiment. In the station control device 21, for example, the CPU develops the computer program installed in the hard disk drive through an interface from a storage medium, in the RAM. Then, the CPU execute the developed computer program, and realizes information processing of the computer program while controlling a hardware configuration such as a storage section, an input section, an output section, an interface, the station storage unit 22, and the station communication device 23 according to necessity. The storage section and the storage unit 12 record the computer program and record data used by the CPU and the generated data. The input section outputs the data generated through the operation by the user and the other device to the CPU and the storage section. The output section outputs the data generated by the CPU and the data of the storage section to the user and the other devices to be

recognizable.

[0049]

The station control device 21 controls the opening/closing of the platform screen door 40 and the
5 switching of the railroad switch 51 of the railroad track 50. The station control device 21 is provided with a railroad switch operating section 25. The railroad switch operating section 25 is realized by the computer program or the cooperation between the
10 computer program and the hardware configuration.

[0050]

The railroad switch operating section 25 outputs the railroad switch switching position data showing a switching position of the railroad switch 51
15 in response to an inquiry of the station related data from the train 2. Also, the railroad switch operating section 25 determines whether the switching of the railroad switch 51 is possible or not, based on a railroad switch switching command from the train.
20 When the railroad switch 51 has been locked in response to the railroad switch switching command from a different train 2, the railroad switch operating section 25 refuses the switching of the railroad switch 51. When the railroad switch 51 has not been
25 locked, the railroad switch operating section 25 carries out the switching of the railroad switch 51 and retains the railroad switch switching command as a part of the railroad switch switching position data (stores in the station storage unit 22). While the
30 railroad switch switching command is retained, the switching state of the railroad switch 51 is maintained (locked). In this case, the railroad switch operating section 25 erases the railroad switch switching command based on a railroad switch release
35 command from a source side train 2. Thus, the lock state of the railroad switch 51 is released. The

station control device 21 of the station I/F device 20 grasps whether or not there is a failure on the traveling route to the other station 3 which is neighbor to the station 3, based on an input from a user and a notice from the station I/F device 20 of the other station 3.

[0051]

Next, the main data which are stored in the storage unit 12, the station storage unit 22 and the center storage unit 32 will be described.

[0052]

FIG. 5A is a block diagram showing the configuration of the storage unit 12 of the on-board device 10 of the signaling system according to the present embodiment. The storage unit 12 contains operation mode data 130, train diagram data 131, station related data 132, train related data 133 and basic data 134 at least.

[0053]

The operation mode data 130 contains data showing in what mode the train 2 travels. The operation mode data 130 is exemplified by the normal mode showing a usual operation and the failure mode showing a case where a failure has occurred on the track (it is the same as the operation mode 105 of FIG. 2). The operation mode data 130 is supplied from the operation control device 30 and is same for all the trains 2 on a railroad line.

[0054]

The train diagram data 131 contains data showing the train diagram of the train 2. The train diagram data 131 is supplied from the operation control device 30 and is different for every train 2. However, the train diagram data 131 may contain only the train diagram of the train 2 and the neighbor train 2. Or, the train diagram data may be data of an

operation interval.

[0055]

When the train 2 is in a stop state, the station related data 132 contains data related to a
5 current station (hereinafter, to be referred to as the station 3A) at which the train 2 is in the stop state, data related to the next station as the station 3 (hereinafter, to be referred to as the station 3B) for the train to be stopped next, data related to a
10 previous station as the station 3 (hereinafter, to be referred to as the station 3C) for the train to have been stopped last time. When the train 2 is traveling, the station related data 132 contains data related to the previous station as the station 3 for
15 the train 2 to have departed and data related to the next station as the station 3. The station related data 132 is updated appropriately (e.g. regularly) and is different for every train 2. The station related data 132 contains the railroad switch switching
20 position data and the inter-station section related data. The railroad switch switching position data shows a switching position of each of the plurality of railroad switches 51 which belongs to the targeted stations 3A, 3B and 3C (the previous station, the
25 current station, the next station), and contains the railroad switch command data (to be described later) of each railroad switch 51. Moreover, the railroad switch switching position data may contain the locked state or the unlocked state of the railroad switch 51.
30 The inter-station section related data shows whether or not there is a failure in an inter-station section (e.g. between the station 3A and the station 3B, between the station 3A and the station 3C) among the targeted stations 3A, 3B and 3C, and whether or not a
35 different train is not in the on-rail state between the stations (the on-rail clearance between the

stations).

[0056]

The train related data 133 contains data showing the moving (traveling) of the train 2 (hereinafter, to be referred to as the train 2A) and a different train 2 (hereinafter, to be referred to as the train 2B) around the train 2A and related to the traveling. The train related data 133 is updated appropriately (e.g. regularly) and is different for every train 2. The train related data 133 contains train position data, traveling permission limit position data, arrival scheduled platform data, traveling direction data, traveling route data and traveling line data. The train position data shows a position (e.g. a distance from a reference point) of each of targeted trains 2 (the train 2A and the train 2B). The reference point is exemplified by a stop position in a starting station and a position of a track antenna beacon provided on the railroad track. The traveling permission limit position data shows a limit position for the targeted train 2 to be permitted to travel (move) (e.g. a distance from the reference point, a distance to a preceding train). The arrival scheduled platform data shows an arrival scheduled platform of the next station for the targeted train 2. The traveling direction data shows a traveling direction of the targeted train 2 (e.g. an inbound direction, an outbound direction, a branch direction). The traveling route data shows a traveling route of the targeted train 2. The traveling line data shows the traveling line (inbound line, outbound line) of the targeted train 2. Note that the arrival scheduled platform data, the traveling direction data, the traveling route data and the traveling line data can be called travel schedule data showing a schedule of travel of the train 2.

Moreover, the train related data 133 may further contain the operation mode data and traveling route request time data. The operation mode data shows the operation mode of the targeted train 2. The traveling
5 route request time data shows a time at which the targeted train 2 issues a traveling route request (switching request of the railroad switch 51) to the station I/F device 20.

[0057]

10 The basic data 134 contains data of a basic configuration of the trains 2, the railroad tracks 50 and so on. The train 2 on the railroad line retains common basic data 134. Here, because the vehicle characteristic is sometimes different for every
15 vehicle, each train 2 retains vehicle characteristic data showing the vehicle characteristic of its own vehicle. The basic data 134 contains linear structure data, station stop position data, limit position data in case of a failure (for branch), and vehicle
20 characteristic data. The linear structure data shows the structure of the railroad track 50, and is exemplified by a position, shape and distance of a curved railroad track, a position and distance of a linear railroad track, a grade of the railroad track,
25 a position of a station, a branch position, existence or non-existence of double track, a position of the rail yard and so on. The station stop position data shows a stop position at every station. The branch limit position data shows a traveling limit position
30 on a branch railroad track of the railroad track 50. The vehicle characteristic data shows structure characteristic and operation characteristic of the vehicle.

[0058]

35 FIG. 5B is a block diagram showing the configuration of the station I/F device 20 of the

signaling system according to the present embodiment.
The station storage unit 22 contains station in-
station related data 142 at least.

[0059]

5 The station in-station related data 142
contains data related to the station 3. The station
in-station related data 142 is different for every
station 3. The station in-station related data 142
contains railroad switch switching position data and
10 inter-station section related data. The railroad
switch switching position data shows a switching
position of each of a plurality of railroad switches
51 which belong to the station 3, and contains
railroad switch command data of each railroad switch
15 51. The railroad switch command data shows the
railroad switch switching command from the train 2 to
each of the plurality of railroad switches 51 which
belong to the station 3. The railroad switch
switching command is a command which instructs the
20 switching of the railroad switch 51, and is related
with data of a command source side train 2 and is
stored. While the railroad switch switching command
is retained, the railroad switch 51 maintains (locks)
the switching state. When the railroad switch
25 switching command is erased in response to a railroad
switch release command from the command source side
train 2, the lock state of the railroad switch 51 is
released. The inter-station section related data
shows whether or not there is a failure between the
30 station 3 and a neighbor station 3. The railroad
switch command data and the inter-station section
related data are transmitted to the on-board device 10
and the operation control device 30, and are stored as
the station related data 132 and the center station
35 related data 152.

[0060]

FIG. 5C is a block diagram showing the configuration of the center (CTR.) storage unit 32 of the operation control device 30 of the signaling system according to the present embodiment. The center storage unit 32 contains center (CTR.) operation mode data 150, center (CTR.) train diagram data 151, center (CTR.) station related data 152, center (CTR.) train related data 153 and center (CTR.) basic data 154 at least.

10 [0061]

The center operation mode data 150 is the same as the operation mode data 130.

[0062]

The center train diagram data 151 contains data showing a train diagram of a railroad line and contains the train diagrams for all the trains 2. The train diagram data may be data of the operation interval.

[0063]

20 The center station related data 152 contains data related to all stations 3. The center station related data 152 contains the railroad switch switching position data and inter-station section related data of the station in-station related data 142 acquired from all the stations 3. The center station related data 152 are appropriately acquired from the station I/F devices 20 of all the stations 3.

[0064]

30 The center train related data 153 contains data related to the moving (traveling) of all the trains 2. The center train related data 153 contains the train position data, the traveling permission limit position data, the arrival scheduled platform data, traveling direction data, the traveling route data and the traveling line data of the train related data 133 acquired from all the trains 2. The center

35

train related data 153 are appropriately acquired from the on-board devices 10 of all the trains 2.

[0065]

5 The center basic data 154 contains data of basic structures of the train 2, the railroad track 50 and so on. The center basic data 154 is the same as the basic data 134.

[0066]

2. Operation

10 Next, the operation of the signaling system according to the present embodiment will be described. In this case, as the operation of the signaling system, a train interval protection in case of traveling of the train 2 between the stations in the
15 usual operation (the normal mode) will be described.

[0067]

 A configuration example of a railroad line to which the signaling system is applied will be described before the explanation of a specific
20 operation.

 FIG. 6 is a schematic diagram showing a configuration example of the railroad line to which the signaling system to according the present embodiment is applied. This railroad line is provided
25 with a railroad track 50 and stations 3. The railroad track 50 is provided with a railroad track 53D, a railroad track 53U and crossovers 53M. The railroad track 53D is a railroad track of an outbound line provided between line ends 161. The railroad track
30 53U is a railroad track of an inbound line provided between tracks ends 161. The crossover 53M is a railroad track provided in the neighborhood of the station 3 to join the railroad track 53D and the railroad track 53U. A plurality of stations 3 are
35 provided between the railroad track 53D and the railroad track 53U to have intervals. In this

railroad line, an area of the station 3 which contains the tracks ends 161 is referred to as an end station portion 160 and an area of the station other than the end station portions 160 is referred to as an
5 intermediate state portion 170. In the signaling system, in the intermediate station portion 170 of this traveling route, the traveling directions of the trains 2 in the inbound line 53U and the outbound line 53D are regarded to be fixed in the usual operation.
10 Below, the operation of the signaling system in such a railroad line will be described.
[0068]

Next, a scene of the train interval protection in the configuration example of the
15 railroad line of FIG. 6 will be described.

FIG. 7 is a diagram schematically showing the scene of the train interval protection in an inter-station traveling of the train in the intermediate station portion 170. In FIG. 7, the attention should
20 be paid to the train 2A which travels between the stations in the intermediate station portion 170. It is supposed that the train 2A travels on the railroad track 53D of the outbound line. The station 3 at which the train 2A has been currently stopped is
25 supposed to be a current station 3A, the station at which the train 2 stops next is supposed to be a next station 3B, the train 2 preceding to the train 2A is supposed to be a train 2B. The railroad switches 51 provided at the current station 3A are supposed to be
30 the railroad switches 51A1 and 51A2 on the side of the railroad track 53D from the side near the station 3A, and are supposed to be the railroad switches 51A3 and 51A4 on the side of the railroad track 53U. The railroad switches 51 provided at the next station 3B
35 are supposed to be the railroad switches 51B1 and 51B2 on the side of the railroad track 53D from the side

near the station 3B and are supposed to be the railroad switches 51B3 and 51B4 on the side of the railroad track 53U.

[0069]

5 As mentioned above, in case of the usual operation, the traveling directions of the trains 2 in the inbound line 53U and the outbound line 53D are fixed in the intermediate station portion 170. That is, the station I/F device 20 of each station 3
10 maintains the traveling route between the stations 3 to constant directions, and maintains the railroad switch switching positions of the railroad switches 51 in predetermined directions. The direction of the traveling route is expressed as the operation mode.
15 In this case, it is the normal mode. The operation control device 30 notifies the operation mode to each train 2 through each station I/F device 20. The operation mode is never changed in principle if there is not the occurrence of a predetermined situation
20 such as a failure. That is, it is presupposed that the train 2 travels on a single line (the railroad track 53D or the railroad track 53U) in the intermediate station portion 170 in the normal mode and does not cross on the railroad tracks 53 to the
25 opposite side by using the crossover 53M. In other words, the inbound line (the railroad track 53U) and the outbound line (the railroad track 53D) are independent from each other. Therefore, in case of the normal mode, it is enough to consider only the
30 train interval protection to the preceding train 2 on the single line in the intermediate station portion 170, for the train interval protection of the train 2. Here, the train 2 checks the passage direction of the railroad switch 51 and the inter-station section
35 state, before traveling between the stations.

[0070]

Note that when it is necessary to cross to another railroad track as in the end station portion 160 (e.g. the time of folding or switching the mode), the traveling route control becomes necessary. That is, a different data communication route is necessary in addition to the intervals to the preceding train 2 and the succeeding train 2. Such a case will be described in a second embodiment.

[0071]

10 Next, a method of exchanging data between the on-board device 10 of the train 2 and a different device will be described.

FIG. 8 is a flow chart showing the operation when the on-board device of the train and the different device exchange data. The on-board device 10 of the train 2 exchange data with the different device (a plurality of different on-board devices 10, a plurality of station I/F devices 20, and the operation control device 30) according to necessity, or regularly. In this case, the attention should be paid to the on-board device 10 of the train 2A in FIG. 7.

[0072]

The operation control device 30 transmits the operation mode (the normal mode) and the train diagram to the on-board device 10 of the train 2A at, for example, the departure time of the train 2A (Step S1). In this case, these data may be transmitted to the on-board device 10 of the train 2A through the station I/F device 20 (Steps S1-01/S1-02). The on-board device 10 of the train 2A stores these data in the storage unit 12 (Step S2).

[0073]

The on-board device 10 (the different train state checking section 72) of the train 2A inquires the train related data to the on-board device 10 of

the different train 2B (Step S3). The on-board device 10 of the train 2B transmits the train related data of the train 2B to the on-board device 10 of the train 2A in response to the inquiry (Step S4). The on-board
5 device 10 (the different train state checking section 72) of the train 2A stores the data in the storage unit 12 (Step S5). The train related data contains the traveling permission limit position data, the arrival scheduled platform data, the traveling
10 direction data, the traveling route data, the traveling line data, and the operation mode data (the traveling route request time data, and the train position data). The different train 2 having received the inquiry is the preceding train 2B related to the
15 train interval protection in this case. Here, in the operation mode in which entering of the train from the crossover 53M is predicted, the inquiry is issued to the trains 2 in a neighbor field (within a predetermined distance) containing the train on an
20 opposite line in addition to the preceding train.
[0074]

The on-board device 10 (the station state checking section 73) of the train 2A inquires the station related data to the station I/F devices 20 of
25 the station 3A and the station 3B (Step S6-1/S6-2). The station I/F device 20 of the station 3A inquires the railroad switch switching positions to the railroad switches 51A1 to 51A4 in response to the inquiry (Step S7). The railroad switches 51A1 to 51A4
30 reply the railroad switch switching positions to the station I/F device 20 of the station 3A (Step S9). In the same way, the station I/F device 20 of the station 3B inquires the switching positions to the railroad switches 51B1 to 51B4 in response to the inquiry (Step
35 S8). The railroad switches 51B1 to 51B4 reply the railroad switch switching positions to the station I/F

device 20 of the station 3B (Step S10). The station I/F devices 20 of the station 3A and the station 3B transmit the station related data of the station 3A and the station 3B to the on-board device 10 of the
5 train 2A (Steps S11/S12). The on-board device 10 (the station state checking section 73) of the train 2A stores the data in the storage unit 12 (Step S13). The station related data contains the railroad switch switching position data, and the inter-station section
10 state data. The stations 3 as an inquiry destination are the current station 3A and the next station 3B related to the train interval protection in this case. Note that when the station I/F device 20 always grasps the railroad switch switching position data, the steps
15 S7 to S10 can be omitted.

[0075]

In this way, the train 2A inquires necessary data to the other devices (a plurality of different on-board devices 10, a plurality of station I/F
20 devices 20, and an operation control device 30) regularly or according to necessity and acquires the data.

[0076]

Next, the train interval protection in case
25 of inter-station traveling of the train in the intermediate station section will be described specifically.

FIG. 9A is a flow chart showing the operation of the train interval protection in case of inter-
30 station traveling of the train in the intermediate station section. The on-board device 10 of the train 2 carries out the traveling route securement and the traveling permission by the train 2 itself based on the exchange of data with the above-mentioned
35 different device. In this case, the attention should be paid to the on-board device 10 of the train 2A in

FIG. 7.

[0077]

The on-board device 10 (the train diagram checking section 95) of the train 2A reads the train
5 diagram from the storage unit 12 and checks the departure time (Step S21). Then, when the departure time comes, the on-board device 10 issues a departure command (Step S22).

[0078]

10 Next, the on-board device 10 (the operation mode checking section 71) of the train 2A reads the operation mode from the storage unit 12 and confirms that the operation mode is the normal mode (Step S23). Thus, it is checked and confirmed that any failure has
15 not occurred on the railroad track 50 and that the traveling route of the train 2A on the railroad track 53D of the outbound line is a traveling route which destines for the next station 3B on the railroad track 53D.

20 [0079]

Next, the on-board device 10 (the different train state checking section 72) of the train 2A checks the state of a different train 2 (the train 2B) (Step S24). For example, this step can be executed
25 like the steps S3 to S5 in FIG. 8. Thus, the on-board device 10 acquires the train related data P1 of the train 2B (the traveling permission limit position data, the arrival scheduled platform data, the traveling direction data, the traveling route data,
30 the traveling line data, and the operation mode data). It is possible to check whether or not the train 2B is in the normal mode based on the operation mode data. The next destination of the train 2B (the station 3) can be checked based on the arrival scheduled platform
35 data, the traveling direction data, the traveling route data, and the traveling line data. By the

traveling permission limit position data, the distance 181 (position 180) to which the train 2A can travel can be confirmed. The train related data P1 can be acquired without passing through the control center 4.

5 [0080]

Next, the on-board device 10 of the train 2A (the station state checking section 73) checks the states of the stations 3 (the station 3A and the station 3B) (Step S25). For example, this step can be
10 executed like the steps S6-1/S6-2 to S13 in FIG. 8. Thus, the station related data P2 and P3 (the railroad switch switching position data, and the inter-station section state data) are acquired. Whether there is a failure in the inter-station section and whether the
15 on-rail train clearance between the stations has been achieved can be checked based on the inter-station section state data. Based on the railroad switch switching position data, it can be checked whether the switching positions of the railroad switches 51A1,
20 51A2, 51B2, 51B1 which are on the traveling route of the train 2A is secured. These station related data P2 and P3 can be acquired without passing through the control center 4.

[0081]

25 Next, the on-board device 10 of the train 2A (the traveling route establishing section 74) checks the on-rail clearance between the stations and determines whether or not the traveling route of the train 2A has been secured, based on the railroad
30 switch switching position data of the station related data P2 and P3 (Step S26). That is, it is determined whether the switching positions of the railroad switches 51A1, 51A2, 51B2, and 51B1 cause any problem in the traveling of the train 2A from the station 3A
35 to the next station 3B. Specifically, whether or not the railroad switches 51 are secured and be locked is

determined in response to the railroad switch switching command from the train 2A. When the traveling route has not been secured (Step S26: No), the traveling route establishing section 74 outputs
5 the railroad switch switching command to the station I/F device 20 of the station 3 (the station 3A, the station 3B) to which the railroad switches 51 to be switched (51A1, 51A2, 51B2, and 51B1) belong (Steps S27-1/S27-2).

10 [0082]

The station I/F device 20 (the railroad switch operating section 25) relates the railroad switch switching command with the train 2A and stores them in the station storage unit 22 (Steps S28/S29).
15 Then, the railroad switch switching signal is outputted to the targeted railroad switches 51 (51A1, 51A2, 51B2, 51B1) (Steps S30/S31) in response to the railroad switch switching command. The targeted railroad switches 51 (51A1, 51A2, 51B2, and 51B1) are
20 switched in response to the railroad switch switching signal (Steps S32/S33), and outputs a switching confirmation signal to the station I/F device 20 (Steps S34/S35). The station I/F device 20 (the railroad switch operating section 25) outputs the
25 railroad switch switching positions to the on-board device 10 of the train 2A in response to the switching confirmation signal (Steps S36/S37). At this time, the railroad switch switching command is stored in the station storage unit 22 so that the railroad switches
30 51 are locked by the station I/F device 20 (the railroad switch operating section 25). For example, the railroad switch switching signal from the station I/F device 20 (the railroad switch operating section 25) is set to the high level, and the signal is
35 continuously outputted. The locking state is continued until the train 2A passes away, the station

I/F device 20 receives the railroad switch release command from the on-board device 10 of the train 2A and the station I/F device 20 erases the railroad switch switching signal. In this case, even if the
5 railroad switch switching signal is erased, the switching position of the railroad switch 51 may be held without being moved just as it is, until the railroad switch switching command is received from the succeeding train to the train 2A.

10 [0083]

The traveling route establishing section 74 of the on-board device 10 determines whether or not the traveling route of the train 2A has been secured in response to the railroad switch switching position
15 (Step S26). When the traveling route has been secured (Step S26: Yes), the traveling route establishing section 74 advances toward step S38. Thus, the traveling route securement for the train 2A completes.
[0084]

20 Note that the determination for the first time may be made as NO at step S26 so that the steps from S27 to S36 are executed, regardless of whether the traveling route has been secured (whether or not the switching positions of the railroad switches 51A1,
25 51A2, 51B2, 51B1 have any problem as for the traveling of the train 2A to the next station 3B). That is, the command (the railroad switch switching command) of the switching and the maintenance (locking) may be outputted to (the station I/F device 20 for) the
30 railroad switch 51 on the traveling route at least once. Thus, the traveling route can be more surely secured.

[0085]

Next, the on-board device 10 of the train 2A
35 (the traveling permission limit position checking section 81) checks the traveling permission limit

position. That is, a distance 181 (position 180) by which the train 2A can travel is checked (Step S38). In a range to the traveling permission limit position, the on-board device 10 of the train 2A issues the
5 traveling permission. Regarding the permission of traveling, a permission range is set in the range between the train 2A and the train 2B (e.g. the distance to the traveling permission limit position). Therefore, it is not necessary to provide a
10 conventional closed section and so on and the facilities can be simplified.
[0086]

Next, the on-board device 10 (the speed profile generating section 94) of the train 2A, i.e.
15 the speed profile generating section 94 generates a speed limit profile indicating an upper limit value of the speed when traveling from the current station 3A to the next station 3B, based on the traveling permission limit position, i.e. based on the distance
20 from the targeted train 2 to the traveling permission limitation position (Step S39). After that, the on-board device 10 (the traveling section 91) of the train 2A starts traveling of the train 2A based on the basic data 134 (the linear structure, the vehicle
25 characteristic and so on) stored in the storage unit 12, while referring to the speed limit profile, so that the train 2A travels to the next station 3B according to the train diagram (Step S40).
[0087]

30 As mentioned above, the train interval protection in the inter-station travel of the train in the intermediate station section is carried out.
[0088]

Here, the release of the locking state of a
35 branch (the railroad switch 51) will be described.

FIG. 9B is a flow chart showing an operation

when the on-board device of the train instructs the station I/F device to release the branch. The train 2A travels on the traveling route secured for the train 2A itself, and passes through the railroad switch 51. The on-board device 10 (the train traveling control section 90) of the train 2A checks its own position (S221). Then, the on-board device 10 determines whether or not the train 2A has passed through the railroad switch 51 (Step S222). When having passed (Step S222: Yes), the on-board device 10 (the train traveling control section 90) issues a railroad switch release command (Step S223) to the station I/F device 20 (Steps S224-1/S224-2). When receiving the railroad switch release command, the station I/F device 20 (the railroad switch operating section 25) outputs a railroad switch release signal to the railroad switch 51 or sets the railroad switch switching command signal to a low level (Steps S225/S226). As a result, the locked state of the railroad switch 51 is released (Steps S227/S228). The railroad switch 51 outputs a release signal indicating the release of the lock state, to the station I/F device 20 (Steps S229/S230). The station I/F device 20 (the railroad switch operating section 25) erases (Steps S231/S232) the stored railroad switch switching command and outputs an erasure confirmation data to the on-board device 10 of the train 2A (Steps S233/S234).

[0089]

In the present embodiment, the on-board device 10 of the train 2 can carry out the train interval protection in the normal mode by receiving the train related data from the different train 2, by receiving the station related data from the station I/F device 20 of the station 3, and by communicating with the station I/F device 20 according to necessity.

That is, in the on-board device 10, mainly, the traveling route securement determining section 70 secures a traveling route (the traveling route protection) and the traveling determining section 80 can permit a passage (the crash protection). As a result, by providing the function of the train interval protection to the on-board device 10, it becomes unnecessary to provide the ATP ground device 232, the station control device 234 and the interlocking device 236 to the control center, unlike the configuration of FIG. 1. Thus, a space for the ATP ground device 232, the station control device 234 and the interlocking device 236 can be reduced and, also, the reduction of the introduction cost becomes possible. Moreover, the maintainability of the equipment can be improved. Moreover, because the train interval protection is carried out by the on-board device as a main device, so that the work of a command issuing member of the control center is changed from the conventional monitoring and controlling operations to the monitoring operation, the work load of the command issuing member and the skill required to the member can be made lower.

[0090]

Also, the branch control in the present embodiment can be regarded as, mainly, steps S23 to S39 in the above train interval protection. In this case, in the branch control of the present embodiment, a series of sequences of the departure and arrival control and the controls from the traveling route establishment to the traveling permission can be realized by the cooperation of the on-board device 10 with the station I/F device 20. Thus, the time until the train 2 starts to travel from the station 3 can be reduced. In this way, the function of the branch control can be accomplished by the on-board device 10

and the station I/F device 20. Thus, the reduction of the space for the devices in the control center and the cost reduction can be accomplished. Moreover, because the on-board device 10 and the station I/F device 20 narrow a sequence range, a process time to the railroad switch switching can be shortened. That is, because the time until the train 2 departs the station 3 can be reduced, the transportation capacity can be reinforced.

10 [0091]

[Second Embodiment]

The signaling system according to a second embodiment of the present invention will be described. In the present embodiment, the train interval protection in case of inter-station traveling of the train 2 in an operation with a failure (a failure mode) in the signaling system having the configuration described in the first embodiment will be described. Below, different points from the first embodiment will be mainly described.

20 [0092]

1. Configuration

The control device of the on-board device 10 will be described.

25 FIG. 10 is a block diagram showing a configuration example of the traveling route securement determining section 70 of the control device of the signaling system according to the present embodiment. The traveling route securement determining section 70 is further provided with a route determining section 75 and a standby position traveling section 76 in addition to the configuration of FIG. 4A. The route determining section 75 determines a route to avoid a failure part when a failure has occurred in the intermediate section between the stations. The standby position traveling

section 76 makes the train 2 travel to a predetermined standby position, when the train travels on the route to avoid the failure part but the route competes against that of the different train 2 in a part of the route.

[0093]

2. Operation

Next, the operation of the signaling system according to the present embodiment will be described. In this case, as the operation of the signaling system, the train interval protection in the inter-station traveling of the train 2 in case of the operation at the time of occurrence of a failure (the failure mode) will be described.

[0094]

The state of the railroad line to which the signaling system is applied will be described previously to the description of a specific operation.

FIG. 11 is a diagram schematically showing the state of the railroad line to which the signaling system according to the present embodiment is applied. FIG. 11 shows the intermediate station portion 170 in FIG. 6. In the intermediate station portion 170, it is shown that the failure has occurred in the intermediate station portion between the station 3A and the station 3B. In other words, it is shown that a failure section 190 has occurred on the railroad track 53D of the outbound line. In this case, the train 2A of the outbound line in the station 3A must take a route Route_A in order to avoid the failure section 190 in case of traveling to the station 3B. Here, the route Route_A enters from the railroad track 53D of the outbound line to the railroad track 53U of the inbound line through the crossover 53M, and returns to the railroad track 53D through another crossover 53M after traveling on the railroad track

53U. On the other hand, the train 2B on the inbound line in the station 3B tries to take the route Route_B just as it is on the railroad track 53U of the inbound line. In this case, the train 2A in the station 3A
5 competes against the train 2B in the station 3B in a part of the route. Below, the operation of the signaling system in the condition of such a railroad line will be described.

[0095]

10 Next, a scene of the train interval protection in the state of the railroad line shown in FIG. 11 (in case of occurrence of the failure) will be described.

FIG. 12 is a diagram schematically showing
15 the scene of the train interval protection in case of inter-station traveling of the train at the time of the failure section occurrence. In FIG. 12, an attention should be paid to the inter-station traveling train 2A in the intermediate station portion
20 170, like FIG. 7. The stations 3 (3A and 3B), the railroad tracks 53 (53U and 53D) and the railroad switches 51 (51A1 to 51A4, and 51B1 to 51B4) are the same as those of FIG. 7. It is supposed that the train 2A in the station 3A does not travel on the
25 railroad track 53D of the outbound line just as it is, and travels on the route Route_A to avoid the failure section 190. It is supposed that the train 2B in the station 3B takes the route Route_B on the railroad track 53U of the inbound line just as it is.

30 [0096]

As mentioned above, when the failure has occurred on the way of the intermediate station portion 170 (the failure section 190) between the stations, the operation control device 30 first
35 instructs the current station 3A and the next station 3B to change the operation mode. The station I/F

devices 20 of the current station 3A and the next station 3B check the on-rail clearance between the stations and then notify the changed operation mode to the trains 2A and 2B in the stopped state at the stations 3A and 3B. The trains 2A and 2B recognize that the traveling routes are the route Route_A and the route Route_B, respectively. The traveling direction of the train 2A and that of the train 2B are opposite to each other and the requested traveling routes compete in a branch section between the railroad switch 51A4 and the railroad switch 51B4. Therefore, the competition must be avoided while the train 2A and the train 2B adjust the traveling route each other. The train 2A checks the state of the train 2B which has stopped at the next station 3B and the switching position states of the railroad switches 51 on the route Route_A before the departure. When the train 2B has acquired a traveling route on the route Route_B, the train 2A advance to a location where the train 2A does not collide with the train 2B (the traveling permission limit position 180A of the train 2A). The train 2A switches the switching positions of the railroad switches 51 along the route Route_A at the timing that the train 2B approaches the current station 3A beyond the traveling permission limit position 180A. Oppositely, when the train 2A acquires the route Route_A as the traveling route before the train 2B acquires, the train 2B waits for passage of the train 2A in front of the traveling permission limit position 180B for the train 2B until the train 2A has passed through the traveling permission limit position 180B for the rain 2B. The trains 2A and 2B continue the monitoring of the states of the acquired traveling routes and the railroad switch switching positions on the acquired traveling routes until the train 2 on the opposite side has

passed through the traveling permission limit position.

[0097]

Next, the train interval protection in case
5 of the inter-station traveling of the train 2 in the operation at the time of occurrence of the failure (the failure mode; the state of the railroad in FIG. 11) will be specifically described.

FIG. 13 is a flow chart showing the operation
10 of the train interval protection in case of inter-station traveling of the train in the operation at the time of occurrence of the failure. The on-board device 10 of the train 2 carries out the traveling route securement and the traveling permission by the
15 train 2 itself based on the exchange of data with the above-mentioned different devices (a plurality of different on-board devices 10, a plurality of station I/F devices 20, and the operation control device 30). Here, the attention should be paid to the on-board
20 device 10 of the train 2A in FIG. 12.

[0098]

The station I/F device 20 of the station 3A
(or the station 3B) recognizes that the failure has occurred between the station 3A and the station 3B
25 (failure section 190) by an input of the user or a detection of a sensor, and transmits it to the operation control device 30 of the control center 4 as the station related data (the inter-station section related data (Step S50)).

30 [0099]

The operation control device 30 changes the operation mode from the normal mode to the failure mode (failure section 190). Then, the operation control device 30 transmits the changed operation mode
35 (the failure mode: the failure section 190) to the station I/F devices 20 of all the stations 3

(containing the station 3A and the station 3B) (Steps S51-1/S51-2).

[0100]

The station I/F device 20 of the station 3A
5 checks the on-rail clearance among the stations (Step S52), notifies that the operation mode has been changed to the failure mode (failure section 190) to the train 2A which has been stopped in the station 3A (Step S54). In the same way, the station I/F device
10 20 of the station 3B checks the on-rail clearance between the stations (Step S53) and notifies that the operation mode has been changed to the failure mode (failure section 190), to the train 2B which has been stopped in the station 3B (Step S55).

15 [0101]

The on-board device 10 (the operation mode checking section 71) of the train 2A checks that the received operation mode is the failure mode (failure section 190) and stores as the operation mode in the
20 storage unit 12 (Step S56). Thus, it is recognized that the next operation of the train 2A is not the operation of the normal mode (the traveling route for the next station 3B on the railroad track 53D). In the same way, the on-board device 10 (the operation
25 mode checking section 71) of the train 2B checks that the received operation mode is the failure mode (failure section 190) and stores as the operation mode in the storage unit 12 (Step S57). Thus, it is recognized that the operation of the train 2B is not
30 the operation of the normal mode (the traveling route for the next station 3A on the railroad track 53U).

[0102]

Next, the on-board device 10 (route determining section 75) of the train 2A calculates the
35 route Route_A as the shortest traveling route to reach the station 3B while avoiding the failure section 190

(Step S58). Then, the on-board device 10 outputs the traveling route securement request (the railroad switch switching command) based on the route Route_A to the station I/F devices 20 of the station 3A and the station 3B, and stores a request time (the traveling route request time) of the traveling route securement. In the same way, the on-board device 10 (route determining section 75) of the train 2B calculates the route Route_B as the shortest traveling route to reach the station 3A while avoiding the failure section 190 (Step S59). Then, the on-board device 10 outputs the request of traveling route securement (the railroad switch switching command) based on the route Route_B to the station I/F devices 20 of the station 3A and the station 3B and stores the request time of the traveling route securement (the traveling route request time). At this time, the station I/F devices 20 of the station 3A and the station 3B accepts the railroad switch switching command with the earlier traveling route request time, and switches the railroad switches 51, and locks the railroad switches 51, as in the step S26 to step S37 in FIG. 9A. However, the request time of the traveling route securement (the traveling route request time) may be the times when the station I/F devices 20 receive the requests of the traveling route securement transmitted from the train 2A and the train 2B. In such a case, the station I/F device 20 necessarily replies the reception time of the request of the traveling route securement to the train 2A and the train 2B regardless of the existence or non-existence of the reception of the traveling route request.

[0103]

Next, the on-board device 10 of the train 2A (the different train state checking section 72) checks

the state of the different train 2 (the train 2B) (Step S60). For example, this step may be executed as at the step S3 to step S5 in FIG. 8. Thus, the train related data P11 of the train 2B (the traveling permission limit position, the arrival scheduled platform, the traveling direction, the traveling route, the traveling line, the operation mode, and the traveling route request time) is acquired. Based on the operation mode, it is possible to check whether or not the train 2B is in the failure mode. The next destination (the station 3A) of the train 2B can be confirmed based on the arrival scheduled platform, the traveling direction, the traveling route, and the traveling line. Based on the traveling permission limit position, the position 180A to which the train 2A can travel can be checked. Based on the traveling route request time, the time when the train 2B requested the traveling route securement to the station I/F devices 20 of the station 3B and the station 3A can be confirmed.

In the same way, the on-board device 10 of the train 2B (the different train state checking section 72) checks the state of the different train 2 (the train 2A) (Step S61). For example, this step can be executed as at the step S3 to step S5 in FIG. 8. Thus, as in the case of the train 2A, the train related data of the train 2A (the traveling permission limit position, the arrival scheduled platform, the traveling direction, the traveling route, the traveling line, the operation mode, and the traveling route request time) is acquired.

[0104]

Next, the on-board device 10 of the train 2A (the station state checking section 73) checks the states of the stations 3 (the station 3A and the station 3B) (Step S62). For example, this step can be

executed as at the steps S6-1/S6-2 to step S12 in FIG. 8. Thus, the station related data P12 and P13 (the railroad switch switching position, the inter-station section state) are acquired. Based on the inter-station section state, it is possible to confirm whether or not there is a failure in the inter-station section. Based on the railroad switch switching position, it is possible to confirm whether or not the switching positions of the railroad switches 51A1, 51A2, 51A4, 51B4, 51B3, 51B1 which are on the route Route_A as the traveling route of the train 2A are secured.

In the same way, the on-board device 10 of the train 2B (the station state checking section 73) confirms the states of the stations 3 (the station 3A, the station 3B) (Step S63). For example, this step can be executed as at the step S6-1/S6-2 to step S13 in FIG. 8. Thus, like a case of the train 2A, the station related data (the railroad switch switching position, and the inter-station section state) are acquired.

[0105]

Next the on-board device 10 of the train 2A (the traveling route establishing section 74) determines whether the traveling route of the train 2A has been secured, based on the railroad switch switching positions of the station related data P12, P13 (Step S64). That is, it is determined whether or not the switching positions of the railroad switches 51A1, 51A2, 51A4, 51B4, 51B3, and 51B1 obstruct the traveling of the train 2A from the current station 3A to the next station 3B. Specifically, it is determined whether or not the railroad switches 51 have been secured and locked in response to the railroad switch switching command from the train 2A. At this time, it is checked whether or not the

traveling route request time of the train 2A is earlier than the traveling route request time of the train 2B.

[0106]

5 When the traveling route request time of the train 2A is later than the traveling route request time of the train 2B so that the traveling route of the train 2A has not been secured (Step S64: No), the on-board device 10 of the train 2A (standby position
10 traveling section 76) travels to the traveling permission limit position 180A (for the branch) in case of the failure. Then, the on-board device 10 stands by until the traveling of the train 2B ends (Step S66). For example, when that the traveling
15 route request time of the train 2A is later than the traveling route request time of the train 2B, the train 2A cannot secure the traveling route because the railroad switches 51 are already locked by the station I/F device 20. Note that the locking state is
20 maintained until the train 2B passes the railroad switches 51 and the train 2B outputs the railroad switch release command to the station I/F device 20. The station I/F device 20 releases the locking state in response to the reception of the railroad switch
25 release command from the train 2B. In this way, by traveling to the traveling permission limit position 180A and standing by there, the travel time to the station 3B by the train 2A can be reduced while securing the safety. The standby position traveling
30 section 76 confirms based on the train related data of the train 2B that the train 2B passes through a position preceding to the traveling permission limit position 180A, and there is no problem even if the train 2A enters the railroad track 53U (Step S67).

35 [0107]

Note that at step S66, the train 2A may

generate a speed pattern such that the train 2A does not pass the traveling permission limit position before a time when the train 2B passes the branch. In this case, the train 2A does not stop at the traveling
5 permission limit position 180A, and travels slowly on the traveling route in front of the position 180A without waiting. By making such an operation, the power efficiency for traveling of the vehicle is improved, compared with a case to stop the vehicle for
10 the standby and then to drive a motor of the vehicle again.

[0108]

After that, the on-board device 10 of the train 2A (the traveling route establishing section 74)
15 outputs the railroad switch switching command to the station I/F device 20 of the station 3 (the station 3A, the station 3B) to which the railroad switches 51 (51A1, 51A2, 51A4, 51B4, 51B3, and 51B1) to be switched belong (Step S68-1/S68-2). The station I/F
20 device 20 (the railroad switch operating section 25) stores the railroad switch switching command in the station storage unit 22 in relation to the train 2A (Steps S69/S70). Then, in response to the railroad switch switching command, the station I/F device 20
25 outputs the railroad switch switching signal to the targeted railroad switches 51 (51A1, 51A2, 51A4, 51B4, 51B3, and 51B1) (Steps S71/S72). The targeted railroad switches 51 (51A1, 51A2, 51A4, 51B4, 51B3, and 51B1) are switched in response to the railroad
30 switch switching signal (Steps S73/S74), and outputs switching confirmation signals to the station I/F device 20 (Steps S75/S76). The station I/F device 20 (the railroad switch operating section 25) outputs the railroad switch switching positions to the on-board
35 device 10 of the train 2A in response to the switching confirmation signals (Steps S77/S78). At this time,

because the railroad switch switching command is stored in the station storage unit 22, the railroad switches 51 are locked by the station I/F device 20 (the railroad switch operating section 25). Note that
5 the locked state is maintained until the train 2A passes the railroad switch 51 and the train 2A outputs the railroad switch release command to the station I/F device 20. The station I/F device 20 releases the locked state in response to the reception of the
10 railroad switch release command from the train 2A. The traveling route establishing section 74 determines whether or not the traveling route of the train 2A has been ensured in response to the railroad switch switching position (Step S64). When the traveling
15 route has been secured (containing a case where the traveling route request time of the train 2A is earlier than the traveling route request time of the train 2B) (Step S64: Yes), the process advances towards step S79. Thus, the train 2A completes the
20 traveling route securement.
[0109]

Note that at step S64, when the traveling route request time of the train 2A is earlier than the traveling route request time of the train 2B, the
25 process of steps S68-1/68-2 to step S78 may be necessarily executed for the first time regardless of whether or not the traveling route has been secured (not shown). That is, the commands (the railroad switch switching command) of switching and retaining
30 (locking) may be necessarily outputted to (the station I/F device 20 of) the railroad switches 51 on the traveling route once. Thus, the traveling route can be more surely secured.
[0110]

35 In the same way, the on-board device 10 of the train 2B (the traveling route establishing section

74) determines whether or not the traveling route of the train 2B has been secured, based on the railroad switch switching positions of the station related data (Step S65). The subsequent process is the same as the case of the train 2A (Step S66 to Step S78). However, in case of the train 2B, when waiting, the train 2B waits in the traveling permission limit position 180B (for branch) in case of the failure.

[0111]

10 Next, the on-board device 10 of the train 2A (the traveling permission limit position checking section 81) checks the traveling permission limit position (Step S79). In this step, regardless of the traveling route request time, the traveling permission limit position does not exist for the train 2A in the relation to the train 2B. However, when a different train 2 exists on the railroad track 53D of the outbound line in the station 3B, the traveling permission limit position associated with the different train 2 exists.

[0112]

 Next, the on-board device 10 of the train 2A (the speed profile generating section 94) generates the speed limit profile to be followed by the train 2A when the train 2A travels from the current position to the next station 3B in the failure mode based on a distance from the targeted train 2 to the traveling permission limit position (not shown). After that, the on-board device 10 of the train 2A (the traveling section 91) starts traveling of the train 2A for the next station 3B based on the basic data 134 while referring to the speed limit profile (Step S81).

[0113]

 In the same way, the on-board device 10 of the train 2B (the traveling permission limit position checking section 81) checks the traveling permission

limit position (Step S80). Next, the on-board device
10 of the train 2B (the speed profile generating
section 94) generates a speed limit profile based on a
distance from the targeted train 2 to the traveling
5 permission limit position (not shown). After that,
the on-board device 10 of the train 2B (the traveling
section 91) starts the traveling of the train 2B for
the next station 3A based on the basic data 134 while
referring to the speed limit profile (Step S82).

10 [0114]

As mentioned above, the train interval
protection is carried out in case of inter-station
traveling of the train in the operation in case of
generation of the failure.

15 [0115]

In the present embodiment, the on-board
device 10 of the train 2 can carry out the train
interval protection in the failure mode, by receiving
the train related data from the different train 2,
20 receiving the station related data from the station
I/F device 20 of the station 3, and communicating with
the different train 2 and the station I/F device 20
according to necessity. That is, in this case, the
same effect as in the first embodiment can be

25 accomplished.

[0116]

[Third Embodiment]

The signaling system to according a third
embodiment of the present invention will be described.

30 In the present embodiment, in the signaling system
which has the configuration described in the second
embodiment, the train interval protection will be
described in case of inter-station traveling of the
train 2 in the end station section in the normal mode.
35 Below, the difference points from the second
embodiment will be mainly described.

[0117]

1. Configuration

The configuration of the present embodiment is the same as that of the signaling system according to the second embodiment.

[0118]

2. Operation

Next, the operation of the signaling system according to the present embodiment will be described.

In this case, as the operation of the signaling system, the train interval protection will be described in case of inter-station traveling of the train 2 in the end station section in the normal mode.

[0119]

The state of the railroad line to which the signaling system is applied will be described before the explanation of the operation.

FIG. 14 is a diagram schematically showing the state of the railroad line to which the signaling system according to the present embodiment is applied. FIG. 14 shows the end station portion 160 in FIG. 6. In the end station portion 160, the station 3A is a terminal (departure) station 3 and the track ends 161 are provided for the railroad track 53D and the railroad track 53U at the end of the station 3A. In this case, the train 2A on the railroad track 53D of the outbound line in the station 3A must take a route Route_C in order to travel onto the railroad track 53U of the inbound line for the purpose of a shuttle operation. Here, the route Route_C is a route entering from the railroad track 53D of the outbound line to the railroad track 53U of the inbound line through the crossover 53M, and traveling on the railroad track 53U to the track end 161. On the other hand, the train 2B exists in the track end 161 of the railroad track 53U of the inbound line, and tries to

travel on the railroad track 53U of the inbound line just as it is, as the route Route_D. In this case, the train 2A on the outbound line in the station 3A competes with the train 2B on the inbound line in a part of the traveling route. Below, the operation of the signaling system in such a railroad line condition will be described.

[0120]

Next, a scene of the train interval protection in the state of the railroad line of FIG. 14 (normal mode (end station portion)) will be described.

FIG. 15 is a diagram schematically showing the scene of the train interval protection in case of inter-station traveling of the train in the end station portion. In FIG. 15, the attention should be paid to the train 2A heading for the track end 161 from the station 3A in end station portion 160. It is supposed that the train 2A in the station 3A travels on the route Route_C from the railroad track 53D of the outbound line to the railroad track 53U of the inbound line. It is supposed that the train 2B at the track end 161 travels on the railroad track 53U of the inbound line as the route Route_D just as it is to head for the station 3A. It is supposed that the railroad switches 51 of the current station 3A are referred to as the railroad switches 51A1 and 51A2 on the railroad track 53D and as the railroad switches 51A3 and 51A4 on the railroad track 53U, in order from the side near the station 3A. The train related data P21 and the station related data P22 are transmitted to the train 2A from the train 2B and the station 3A.

[0121]

The operations of the train 2A and the train 2B in this case are the same as those of the second embodiment except that the train 2B has to travel

earlier (the train 2B has a priority) and the train 2A do not cross to the railroad track 53D (route Route_C) again. That is, in the second embodiment, regarding the control of FIG. 13, a case where the step S64 is
5 necessarily set to a No state and step S65 is necessarily set to a YES state can be considered. This is determined from the facts that the station 3A is the station 3 of the end station portion 160 and the operation mode is the normal mode.

10 [0122]

In this way, in the end station portion 160, the train 2 can carry out a shuttle operation.

[0123]

In this case, too, the effects of the first
15 and second embodiments can be obtained.

[0124]

The program and the data configuration of the present invention are recorded on a computer-readable storage medium of the computer and may be read into
20 the information processing unit from the storage medium.

[0125]

The present invention is not limited to any of the above embodiments, and the above embodiments
25 can be modified appropriately in the range of the technical thought of the present invention.

[0126]

The present invention has been described with reference to the above embodiments. However, it would
30 be apparent to a person skilled in the art that these embodiments are merely provided to describe the present invention. These embodiments have not to use to interpret the attached claims to limit meaning.

[0127]

35 A part or the whole of the above-mentioned embodiments and examples can be described as in the

following supplemental notes, but are not limited to them.

[0128]

5 The present invention is related to the on-board device which is loaded on the moving vehicle to traveling on the track. The on-board device includes a control device which controls the traveling of the moving vehicle. The control device includes an operation data acquisition section, a route
10 determining section, a traveling route securement determining section and a traveling determining section. The operation data acquiring section acquires the failure data that indicates the failure on the track. The route determining section
15 determines the traveling route in case of the failure occurrence based on the failure data. The traveling route securement determining section determines the securement of the traveling route based on the station related data that indicates data related to the branch
20 and that is acquired from the the station interface device of the station to which the branch belongs, and the different moving vehicle related data that indicates data related to a different moving vehicle and that is acquired from the different moving vehicle
25 which competes in at least a part of the traveling route. The traveling determining section determines the traveling of the moving vehicle on the secured traveling route based on the different moving vehicle related data.

30 In the on-board device of the present invention which has such a configuration, even if the failure occurs on the track, the route determining section determines an appropriate route in correspondence to the failure, the traveling route
35 securement determining section determines the traveling route securement (the traveling route

protection), and the traveling determining section can determine the traveling (the collision protection). That is, even if the failure is proved, it is possible to travel to avoid the failure autonomously without
5 passing through the control center. Thus, the efficiency of the processing is improved, the devices (the ATP ground device, the station control device, and the interlocking device) of the control center can be made unnecessary, and the space for the devices and
10 so on can be reduced. Also, facility cost can be reduced and the treatment of the devices becomes easy.
[0129]

In the above-mentioned on-board device, the traveling route securing determining section may
15 include the different train state checking section and the station state checking section. The different train state checking section inquires the different moving vehicle related data to the different moving vehicle. The station state checking section inquires
20 the station related data to the station to which the branch belongs.

In the on-board device of the present invention which has such a configuration, the different train state checking section inquires and
25 acquires the different moving vehicle related data, and the station state checking section inquires and acquires the station related data. That is, the inquiry and acquisition of the necessary data when determining the traveling route securement (the
30 traveling route protection) can be carried out without passing through the control center.
[0130]

In the above-mentioned on-board device, the different moving vehicle related data may contain
35 request time data indicating a time when the different moving vehicle outputs the branch switching command.

The traveling route securement determining section may confirm whether the traveling route has been secured based on the station related data and the different moving vehicle related data. When the request time
5 data is earlier than the time that the train outputted the branch switching command, so that the traveling route is not secured, the train may standby in a predetermined position. The branch switching command may be outputted to secure the traveling route after
10 the different moving vehicle travels.

In the on-board device of the present invention which has such a configuration, the competition with the different moving vehicle can be more surely avoided without passing through the
15 control center, and the traveling route can be more surely secured (the traveling route protection).
[0131]

In the above-mentioned on-board device, the traveling route securement determining section may
20 make the moving vehicle travel to the predetermined stand-by position in case of the stand-by when the traveling route has not been secured.

In the on-board device of the present invention which has such a configuration, the
25 traveling time of the moving vehicle to a destination can be reduced while securing the safety, by traveling to an appropriate standby position, in case of using the traveling route of the moving vehicle which competes with the different moving vehicle.
30 [0132]

In the above on-board device, the different moving vehicle related data may contain the traveling permission limit position data indicating a range
where the moving vehicle is permitted to travel in
35 case of the failure around the different moving vehicle. The traveling determining section may

determine the traveling of the moving vehicle in the range which the traveling is permitted, based on the traveling permission limit position data.

In the on-board device of the present invention which has such a configuration, because a passage permission section determines the traveling of the moving vehicle in the passage permission range around the different moving vehicle, the moving vehicle never collides with the different moving vehicle. Also, because the permission range is set as a range (e.g. a distance) between the moving vehicle and the different moving vehicle, it is not necessary to provide a conventional block section and so on and the facilities can be simplified.

[0133]

A signaling system of the present invention has a plurality of on-board devices and a plurality of station interface devices. The plurality of on-board devices are loaded in a plurality of moving vehicles traveling on the track and described in any one of the above paragraphs. The plurality of station interface devices are bi-directionally communicable, are arranged in the plurality of stations provided along the track, and control the plurality of branches belonging to the plurality of stations.

In the signaling system of the present invention which has such a configuration, even if a failure has occurred on the track, the on-board device determines an appropriate traveling route in correspondence to the failure based on the data from the different on-board device and the data from the plurality of station interface devices, determines the traveling route securement (the traveling route protection), and determines the traveling (collision protection). That is, it is possible to avoid the traveling autonomously without passing through the

control center and to make it possible to operate, even if the failure is has occurred. Thus, the efficiency of the processing is improved, and the devices (such as the ATP ground device, the station
5 control device, and the interlocking device) of the control center can be made unnecessary. Moreover, the space for the devices and so on can be reduced, the facility cost can be reduced and the treatment of the equipment becomes easy.

10 [0134]

A control method of a moving vehicle of the present invention is related to a control method of a moving vehicle traveling on a track. The control method includes: acquiring failure data indicating a
15 failure on the track by an on-board device of the moving vehicle; determining a traveling route in case of occurrence of the failure based on the failure data by the on-board device; securing the traveling route by the on-board device based on station related data
20 that is acquired from a station interface device of a station to which a branch on the traveling route belongs and which indicates data of the branch, and different moving vehicle related data that is acquired from a different moving vehicle competing in at least
25 a part of the traveling route and that indicates data of the different moving vehicle; and determining the traveling of the moving vehicle on the secured traveling route based on the different moving vehicle related data by the on-board device.

30 In the control method of the moving vehicle of the present invention which has such a configuration, even if the failure has occurred on the track, the on-board device can determine an appropriate route in correspondence to the failure,
35 determine the traveling route securement (the traveling route protection) and determine the

traveling (crash protection). That is, even when a failure is has occurred, it is possible to avoid the failure autonomously without passing through the control center and to make the operation possible.

5 Thus, the efficiency of the processing is improved, and the devices (such as the ATP ground device, the station control device, and the interlocking device) of the control center can be made unnecessary. Moreover, the space for the devices and so on can be
10 reduced, the facility cost can be reduced and the treatment of the equipment becomes easy.

[0135]

In the above control method of the moving vehicle, the securing the traveling route may include:
15 inquiring the different moving vehicle related data to the different moving vehicle by the on-board device; and inquiring the station related data to the station to which the branch belongs by the on-board device.

In the control method of the moving vehicle
20 of the present invention which has such a configuration, the on-board device inquires and acquires the different moving vehicle related data and inquires and acquires the station related data. That is, the on-board device can inquire and acquire the
25 necessary data without passing through the control center when determining the traveling route securement (the traveling route protection).

[0136]

In the above control method of the moving
30 vehicle, the different moving vehicle related data may contain a request time data which indicates a time when the different moving vehicle outputted a command of switching of the branch. The securing the traveling route may include: checking whether the
35 traveling route has been secured, based on the station related data and the different moving vehicle related

data; standing by at a predetermined stand-by position, if there is request time data that is earlier than the time when the branch switching command is outputted from the moving vehicle and if
5 the traveling route has not been secured; and outputting the branch switching command for the traveling route to be secured after the different moving vehicle travels.

In the above control method of the moving
10 vehicle of the present invention which has such a configuration, it is possible to more surely avoid the competition with the different moving vehicle without passing through the control center, and to more surely determine the traveling route securement (traveling
15 route protection).

[0137]

In the control method of the moving vehicle, the securing the traveling route may include: makes the moving vehicle travel to the predetermined stand-
20 by position in case of the stand-by when the traveling route has not been secured.

In the above control method of the moving vehicle of the present invention which has such a configuration, when the traveling route of the moving
25 vehicle which competes with the different moving vehicle is used, the traveling time of the moving vehicle to the destination can be reduced while securing the safety, by traveling to the appropriate standby position.

30 [0138]

In the above control method of the moving vehicle, the different moving vehicle related data may contain traveling permission limit position data which indicates a range where the moving vehicle is
35 permitted to travel in case of the failure around the different moving vehicle. The determining the

traveling route may include: determining the traveling of the moving vehicle in the range where the moving vehicle is permitted to travel, based on the traveling permission limit position data.

5 In the above control method of the moving vehicle of the present invention which has such a configuration, because the on-board device permits the traveling of the moving vehicle in the passage permission range around the different moving vehicle,
10 the moving vehicle never collides with the different moving vehicle. Also, because the permission range is set in a range (e.g. the distance) between the moving vehicle and the different moving vehicle, it is not necessary to provide a conventional block section and
15 so on and the facilities can be simplified.

[0139]

 The storage medium of the present invention stores a program to make a computer execute the control method of a moving vehicle according to any
20 one of the above paragraphs.

CLAIMS

1. An on-board device loaded on a moving vehicle traveling on a track, and comprising a control device configured to control the traveling of the moving
5 vehicle, wherein the control device comprises:
 - an operation data acquiring section configured to acquire failure data indicating a failure on the track;
 - a route determining section configured to
10 determine a traveling route in case of occurrence of the failure based on the failure data;
 - a traveling route securement determining section configured to determine securement of the traveling route based on station related data that is
15 acquired from a station interface device of a station to which a branch on the route belongs, and which indicates data of the branch, and different moving vehicle related data that is acquired from a different moving vehicle competing in at least a part of the
20 traveling route and that indicates data of the different moving vehicle; and
 - a traveling determining section configured to determine the traveling of the moving vehicle on the secured traveling route based on the different moving
25 vehicle related data.
2. The on-board device according to claim 1, wherein the traveling route securement determining section comprises:
30
 - a different train state checking section configured to inquire the different moving vehicle related data to the different moving vehicle; and
 - a station state checking section configured to inquire the station related data to the station to
35 which the branch belongs.

3. The on-board device according to claim 2,
wherein the different moving vehicle related data
contains a request time data which indicates a time
when the different moving vehicle outputs a command of
5 switching of the branch,

wherein the traveling route securement
determining section:

checks whether the traveling route has been
secured, based on the station related data and the
10 different moving vehicle related data,

stands by at a predetermined stand-by
position, if there is request time data that is
earlier than the time when the branch switching
command is outputted from the moving vehicle and if
15 the traveling route has not been secured; and

outputs the branch switching command for the
traveling route to be secured after the different
moving vehicle travels.

20 4. The on-board device according to claim 3,
wherein the traveling route securement determining
section makes the moving vehicle travel to the
predetermined stand-by position in case of the stand-
by when the traveling route has not been secured.

25

5. The on-board device according to any one of
claims 1 to 4, wherein the different moving vehicle
related data contains traveling permission limit
position data which indicates a range where the moving
30 vehicle is permitted to travel in case of the failure
around the different moving vehicle, and

wherein the traveling determining section
determines the traveling of the moving vehicle in the
range where the moving vehicle is permitted to travel,
35 based on the traveling permission limit position data.

6. A signaling system comprising:

a plurality of on-board devices, each of which is specified in any one of claims 1 to 5 and is loaded in one of a plurality of moving vehicles

5 traveling on a track; and

a plurality of station interface devices, each of which is bi-directionally communicable with each of the plurality of on-board devices, is arranged in one of a plurality of stations provided along the
10 track, and controls one of a plurality of branches that belongs to the one station.

7. A control method of a moving vehicle traveling on a track, comprising:

15 acquiring failure data indicating a failure on the track by an on-board device of the moving vehicle;

determining a traveling route in case of occurrence of the failure based on the failure data by
20 the on-board device;

securing the traveling route by the on-board device based on station related data that is acquired from a station interface device of a station to which a branch on the traveling route belongs and which
25 indicates data of the branch, and different moving vehicle related data that is acquired from a different moving vehicle competing in at least a part of the traveling route and that indicates data of the different moving vehicle; and

30 determining the traveling of the moving vehicle on the secured traveling route based on the different moving vehicle related data by the on-board device.

35 8. The control method of the moving vehicle according to claim 7, wherein the securing the

traveling route comprises:

inquiring the different moving vehicle related data to the different moving vehicle by the on-board device; and

5 inquiring the station related data to the station to which the branch belongs by the on-board device.

9. The control method of the moving vehicle according to claim 8, wherein the different moving vehicle related data contains a request time data which indicates a time when the different moving vehicle outputted a command of switching of the branch,

15 wherein the securing the traveling route comprises:

checking whether the traveling route has been secured, based on the station related data and the different moving vehicle related data;

20 standing by at a predetermined stand-by position, if there is request time data that is earlier than the time when the branch switching command is outputted from the moving vehicle and if the traveling route has not been secured; and

25 outputting the branch switching command for the traveling route to be secured after the different moving vehicle travels.

10. The control method of the moving vehicle according to claim 9, wherein the securing the traveling route comprises:

making the moving vehicle travel to the predetermined stand-by position in case of the stand-by when the traveling route has not been secured.

35

11. The control method of the moving vehicle

according to any one of claims 7 to 9, wherein the
different moving vehicle related data contains
traveling permission limit position data which
indicates a range where the moving vehicle is
5 permitted to travel in case of the failure around the
different moving vehicle, and

wherein the determining the traveling route
comprises:

determining the traveling of the moving
10 vehicle in the range where the moving vehicle is
permitted to travel, based on the traveling permission
limit position data.

12. A non-transitory recording medium which
15 stores a program to make a computer execute a control
method of a moving vehicle according to any one of
claims 7 to 11.